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PHYTOTOXICOLOGY INVESTIGATIONS IN THE CORNWALL AREA OF ONTARIO IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), AND THE ALUMINUM COMPANY OF AMERICA (ALCOA), MASSENA, NEW YORK - 1985

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Air Resources Branch

Phytotoxicology Section

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EXECUTIVE SUMMARY

A Federal-Provincial study with participation by several government agencies, including the Phytotoxicology Section, Ontario Ministry of the Environment, has been ongoing in the Cornwall area for several years.

Phytotoxicology investigations, involving vegetation sampling and injury observations, to assess the impact of airborne fluoride emissions from the Reynolds Metals Company (RMC) and from the Aluminum company of America (ALCOA), both in Massena, New York, on vegetation in the Cornwall and Long Sault areas of Ontario, have been conducted during each growing season since 1969 and 1976, respectively.

The results of the most recent RMC and ALCOA survey study findings in 1985 are presented in this report.

In the RMC survey area, which includes the St. Regis Indian Reserve on Cornwall Island and extends to the north and northeast of

the City of Cornwall, the highest fluoride levels in 1985 were, as in earlier years, detected in vegetation in the south shore bridge area (the immediate impact area) of the island, with levels decreasing sharply with increasing distance from this area. Overall, fluoride levels in vegetation collected to the north and northeast of RMC were lower in 1985 with the forage results showing a marked reduction compared to 1984. There was only a single exceedence of the MOE Ontario forage criteria in 1985 compared to eleven in 1984. The severity of F-like injury to sensitive vegetation (e.g. wild grape) also was slightly reduced compared to 1984, with the most adverse effects (as in all past years) being observed in or near the island's south shore bridge area which is directly across the river to the northeast of RMC.

In the Long Sault survey area, to the north and northeast of ALCOA, foliar fluoride levels at most collection sites also were reduced compared to 1984. A corresponding decrease in foliar injury severity also was documented in 1985.

In light of the 1985 weather data for the Cornwall area and the 1985 air monitoring program results on Cornwall Island in the RMC survey area, it is believed that the decrease in foliar fluoride contamination found in both the RMC and ALCOA survey areas in 1985 was largely weather related.

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PHYTOTOXICOLOGY INVESTIGATIONS IN THE CORNWALL AREA OF ONTARIO IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), AND THE ALUMINUM COMPANY OF AMERICA (ALCOA), MASSENA, NEW YORK - 1985

I. INTRODUCTION

A Federal-Provincial study with participation by Environment Canada, Agriculture Canada, National Health and Welfare, Indian and Northern Affairs and the Ontario Ministry of the Environment was established in the Cornwall area in 1975. Prior to this time, the Phytotoxicology Section had been conducting annual vegetation assessment programs and responding to complaints concerning the adverse effects of airborne fluoride emissions on vegetation and cattle since 1969. The source of the fluoride emissions was identified as the Reynolds Metals Co., located in Massena, New York. The study was broadened in 1975 in view of the transboundary nature of the emissions and their impact on the St. Regis Mohawk Indian Reserve on Cornwall Island.

In 1976, the Phytotoxicology Section also initiated vegetation survey activity in the Long Sault area, downwind of the larger Aluminum Co. of America plant (ALCOA) located in Massena N.Y. to the west of the RMC plant.

Both of these vegetation assessment programs have been ongoing in the Cornwall and Long Sault areas without interruption since 1969 and 1976, respectively.

The results of the most recent 1985 study findings are presented in this report.

II. RMC ASSESSMENT PROGRAM

A. PRIMARY OBJECTIVE

The primary objective of the RMC assessment program was to determine the degree and extent of fluoride contamination and injury to vegetation and to compare these findings with previous years' results.

B. SAMPLES COLLECTED FOR CHEMICAL ANALYSIS

Maple Foliage

During late August, 1985, foliage was sampled from exposed middle branches of all regular Manitoba maple sites sampled in 1984 on Cornwall Island and the Ontario mainland to the north and northeast of RMC (see Figure 1). Moreover, in June, foliage was sampled from a mid-sized Manitoba maple (site 21) near the south shore of Cornwall Island to the west of the bridge. In total, seventeen Manitoba maple sites were sampled throughout the survey area during 1985.

In addition to the samples of Manitoba maple, red maple foliage was collected monthly during June through August from the exposed southern periphery of the two woodlots on Cornwall Island to the west and east of the bridge. Slightly more remote to the northeast, red maple foliage also was sampled from the Lillian Point property in August and from the N. Point Property in July and August (see Figure 2).

Pine Needles

During mid-September, current year's (1985) Eastern white pine needles were collected from the same pines sampled in previous years in the south shore area to the west and east of the bridge and from the more remote Elijah Benedict property near the centre of the island (see Figure 2).

Forage

Forage was collected at all sites sampled in 1984. As in previous years since 1978, the forage sites were sampled monthly during May through October. Overall, during the 1985 growing season, forage was collected from twelve sites on Cornwall Island and from three sites on the Ontario mainland including a remote site near Lunenburg (see Figure 1).

Sweet Corn

In early August, a composite sample of corn foliage was collected from the A. Boots garden to the neighbouring northeast of the immediate impact area (south shore bridge area), and also from the more remote R. Seymour garden at the west end of the island (see Figure 3). The mid-leaf section (middle 1/3 of leaf) was cut from one or two middle leaves of several white corn plants in both gardens.

Moss Bag Survey

In mid May, on the Elijah Benedict property, at the center of the island, three moss bag stations were established. One moss bag was placed atop the gate post of the Environment Canada air monitoring station and another atop a fence post at the cemetery on the hill to the neighbouring east. The third moss bag was placed at a height

of about 3 m on a hydro pole in the hayfield beside the barn to the south of the monitor. In addition, a moss bag was established on a hydro pole near the P. Martin residence in the south shore bridge area of the island, closer to RMC. On the Benedict property, the moss bag at the monitor was partially protected by neighbouring mature sugar maples and a church building. The other sites on this property, like the moss bag station in the south shore bridge area, were better exposed to RMC emissions. The bags were exchanged monthly during each forage collection through to mid-October.

C. FOLIAR SAMPLES COLLECTED FOR HISTOLOGICAL AND PATHOLOGICAL EXAMINATION DURING 1985

From Cornwall Island, during June through August, seventeen foliar samples were collected for histological examination and a single foliage sample was collected for pathological examination (see Table 9 and Figures 2 and 3).

D. PROCESSING OF SAMPLES COLLECTED FOR CHEMICAL ANALYSIS

All samples collected for chemical analysis first were processed in the Phytotoxicology processing laboratory and then were submitted for analysis on a dry weight basis to the Inorganic Trace Contaminants Section, Laboratory Services Branch, MOE.

The regular August maple foliage collection was processed on a washed and unwashed basis. The two corn foliage samples were washed. All other samples, including the forage, pine needle and moss bag samples, were processed on an unwashed basis. All samples were analyzed for fluoride. In addition, the regular Manitoba maple collection in August was analyzed for aluminum and sodium.

E. VISUAL INJURY ASSESSMENT PROGRAM

Injury assessments of native vegetation (wild grape, cherry and maple trees, etc.) were conducted in the survey area during June through August, with the pine needle injury assessments being performed through to mid-September.

In addition, cultivated grape plants on four properties (A. Boots, E. Benedict, N. Gaspy and A. Lazore), and vegetable plantings in seventeen gardens across Cornwall Island were examined during July through August. Gladiolus plants sighted on the island also were assessed for injury through to late August.

III. RESULTS OF 1985 ASSESSMENT PROGRAM

A. ANALYTICAL RESULTS FOR FOLIAGE AND PINE NEEDLES

Manitoba Maple Foliage Results

In late August, as in previous years, the highest fluoride levels were detected on Cornwall Island at collection site 1 (unwashed - 337 ppm; washed - 228 ppm) in the south shore bridge area (just east of the bridge) with levels sharply decreasing with distance from this area (Table 1). The unwashed foliage collected in June at maple site 21 in the S shore area to the west of the bridge had a fluoride level of 70 ppm.

The degree of particulate surface contamination washed from the foliage collected at all Manitoba sites in August was calculated and compared to the corresponding earlier years' particulate removal values (Table 2). This comparison revealed that the average degree of particulate surface

contamination washed from the foliage at most sites in August was slightly greater than in 1984 but less than in 1982-83.

As shown in Table 1, fluoride levels in both the unwashed and washed foliage samples collected in August, 1985 were slightly lower than the corresponding 1984 results for most stations. However, in comparing the August unwashed results detected over the past eight years (Table 3), it is apparent that levels of fluoride have been more elevated in maple foliage in the survey area in recent years (1981-85). Nonetheless, compared to 1977 and earlier years' results, even the highest levels found in recent years (1981 through 1985) are below levels detected prior to and following abatement activity at RMC in 1972/73.

The corresponding unwashed aluminum and sodium results for August, 1985 are shown and compared to earlier years' data in Table 4. As with fluoride, the highest aluminum and sodium levels were detected at foliage collection Site 1 in the south shore immediate impact area. The foliar levels of aluminum and sodium detected across the survey area in August were not appreciably different from the 1982-84 results.

Red Maple Foliage Results

The fluoride results for the unwashed red maple foliage samples collected from Cornwall Island to the neighbouring north (west of bridge) and northeast (east of bridge) of RMC during 1985 are shown in Table 5 on the following page.

Table 5

Red Maple Foliage (Unwashed) Fluoride Results for 1985 Compared to 1984 and 1982 Results

Location	Mean Fluoride Concentration (ppm-dry wt.)				
	[1]June	[1]July	[1]August, 1985	August- [2]1984	[3]1982
	South Shore Bridge Area				
West of Bridge	18	28	22	134	118
East of Bridge	104	59	139	278	99
	To Neighbouring Northeast				
Lilian Point	-	-	61	-	-
Noah Point	-	64	88	172	-

[1] mean of duplicate sample results
[2] mean of triplicate results
[3] based on a single sample

As with Manitoba maple foliage, the highest fluoride levels in red maple foliage were detected in the south shore immediate impact area just east of the bridge.

Table 5 also shows that the unwashed foliar fluoride levels detected at all red maple collection sites in August were markedly lower than the corresponding 1984 results, even more so than for Manitoba maple, with the most dramatic reduction being in the south shore area to the west of the bridge. The foliar levels detected in the south shore area to the west of the bridge (to the north of RMC) also were markedly lower than the corresponding 1982 levels.

Corn Foliage Results

The washed corn foliage (mid-leaf sections) collected in August from the A. Boots garden to the neighbouring northeast of the south shore bridge area, and from the more remote R. Seymour garden at the west end of the island, were found to have similar fluoride levels (4 and 3 ppm, respectively). The mid-leaf sections collected from the Boots property displayed a distinct zone of chlorotic tissue on both sides of the mid rib, with the foliage collected from the Seymour property being healthy.

Pine Needles Results

The fluoride levels detected in the unwashed current years' Eastern white pine needles collected from Cornwall Island in 1985 are compared to corresponding previous years' results in Table 6 on the following page.

Table 6

Fluoride Levels in Unwashed Current Years' White Pine Needles Collected in 1982 through 1985

Sampling Location	Fluoride Concentration (ppm-dry wt. basis)			
	1982[3] Sept. 4	1983[2] Aug. 8-10	1984[1] Sept. 13	1985[2] Sept. 12
	South Shore Bridge Area			
West of Bridge	41	20	36	9
East of Bridge	59	21	34	13
	Centre of Island			
E. Benedict	23	6	11	6

[1] based on a single sample
[2] mean of duplicate sample results
[3] mean of triplicate sample results

As with Manitoba maple and red maple, the highest fluoride levels were detected in the pine needles from the south shore area to the immediate east of the bridge. In 1985, fluoride concentrations in the unwashed pine needles collected from the island were reduced compared to 1984 levels, with the most dramatic decrease occurring in the south shore immediate impact area. Overall, the 1985 pine needle results generally were lower than the 1983 and 1982 results.

B. COMPARISON OF UNWASHED MAPLE FOLIAGE RESULTS TO CORRESPONDING FOLIAGE GUIDELINES ESTABLISHED BY THE PHYTOTOXICOLOGY SECTION

Fluoride

The mean fluoride level detected at all Manitoba and red maple foliage collection sites in the RMC survey area during 1985 exceeded the 15 ppm upper limit of normal for a rural area. Unwashed fluoride levels detected at 8 of the 17 Manitoba sites and at 3 of the 4 red maple collection sites sampled during June through August also were in excess of the urban foliage guideline (35 ppm). There were a total of 14 exceedances of the urban guideline in 1985 compared to 20 in 1984. In 1984, the rural guideline was exceeded at all sites but one.

Aluminum and Sodium

Even the highest aluminum level (217 ppm) found at Manitoba maple collection Site I in August was, as in earlier years, well below the 500 ppm guideline for unwashed foliage.

As in 1984, the mean foliar level of sodium detected at most Manitoba maple collection sites in late August exceeded the 50 ppm rural guideline. Only the sodium level at Site 1 (420 ppm) in the south shore bridge area in August was found, as in previous years, to exceed the 350 urban guideline.

C. ANALYTICAL RESULTS FOR FORAGE

As in earlier years, the highest monthly fluoride levels in unwashed forage were detected at the Bridge site, in the

south shore bridge area of Cornwall Island. Fluoride levels in forage were found to decrease with distance from this area (Table 7).

As shown in Table 7, the six month (May - August) fluoride growing season means for 1985 were, in most cases, markedly lower than in 1984. Table 7 also shows that the 1985 fluoride means were the lowest detected at most sites since monthly forage sampling on a six month basis began in 1978.

Prior to 1978, forage was collected only in June, July and August and any comparison to the pre-1978 results must be based on three month (June - August) averages. A comparison of the more recent June - August forage means with the corresponding pre-1978 means further shows that the 1985 forage levels were amongst the lowest to be detected in the RMC survey area since forage sampling began in 1969 (Table 8).

D. COMPARISON OF THE FORAGE RESULTS TO MOE ONTARIO FORAGE CRITERIA

As in most previous years, only at the Bridge forage site in the south shore immediate impact area, was the fluoride mean for the growing season found to exceed the Ontario growing season criterion for unwashed forage (35 ppm). In contrast with earlier years, during 1985 the single month (80 ppm) and two month (60 ppm) criteria were not exceeded at any of the forage collection sites.

In 1985, there was only a single exceedance of the Ontario forage criteria compared to 11 in 1984, four in 1983 and three in 1982. In 1984, the six month (35 ppm) and two month (60 ppm) criteria were exceeded at the N. Point forage

site for the first time since 1978, contributing to the higher number of exceedances in 1984.

E. MOSS SURVEY RESULTS

The monthly fluoride results for the four moss bag stations on the island are presented in Table 8 below.

Table 8

Moss Bag Fluoride Levels Detected on Cornwall Island during the 1985 Growing Season

Exposure Period	Fluoride Concentration* - ppm, dry wt.			
	South Shore Bridge Site	E. Benedict Property		
		Monitor	Field	Cemetery
May 14 - June 19	48	4	34	14
June 19 - July 17	43	1	4	12
July 17 - Aug 7	159	37	44	71
Aug 7 - Sept 12	34	31	28	54
Sept 12 - Oct 10	66	9	16	21

* based on a single sample

Similar to the maple foliage, pine needle and forage results, the highest fluoride levels in moss generally were detected in the south shore bridge area.

On the more remote E. Benedict property, fluoride levels tended to be higher at the field and cemetery moss sites than at the monitor site. Therefore, it would appear that the mature sugar maple trees and church building neighbouring the

monitor site have, through interfering with exposure to RMC emissions, contributed to the lower fluoride levels found at the latter site.

F. INJURY ASSESSMENT FINDINGS

Wild Grape

On Cornwall Island, by late August, as in earlier years, the most severe F-like injury on wild grape foliage was observed in the south shore immediate impact area at a site west of the bridge next to the river. In August, at this site, the more adversely affected leaves displayed distinct F-like injury (reddish marginal necrosis and intercostal spots with a distinct dark band separating the injured and healthy tissue) of moderate (11-35%) severity, with the overall injury to the patch being rated as light (2-10%). All other wild grape plants examined towards the end of the summer in the south shore area to the neighbouring east and west of the bridge displayed trace (>0-1%) to light (2-10%) foliar injury.

The observations in August beyond the immediate impact area also revealed distinct F-like injury on mature grape foliage across an area extending from the vicinity of J. Charrow (N. of RMC) through to the P. Hopps forage site (3.1 km NE of RMC). The injury severity observed throughout this area was mostly trace (>0-1%) with a few sites displaying some older leaves with light (2-10%) injury.

Observations in July and August on more remote wild grape plants over the larger area between the west and east ends of the island revealed either no injury or inconsequential tip injury only on a few leaves. Unlike previous years, the well exposed wild grape patch assessed annually on the Elijah

Benedict property, at the center of the island, remained injury-free during June through August.

In relation to more recent years' observations, in 1985 the severity of F-like foliar injury on wild grape plants in the south shore immediate impact area and at other locations on Cornwall Island was judged to be less severe.

Staghorn Sumac

As early as June, sumacs in the south shore immediate impact area to the neighbouring west and east of the bridge displayed several compound leaves/leaflets with marginal black or dark brown necrosis and intercostal necrosis or spotting. Several affected leaves also were savoyed and cupped with both youngest and mature leaves being injured. As in 1983 and 1984, moderate to severe injury was observed on the more adversely affected leaves. Similar injury of lesser severity (light overall) also was observed on sumacs growing just beyond the south shore bridge area on the Lillian Point property to the northeast. Sumacs examined at more remote locations on Cornwall Island were in a normal condition. This suggests that RMC emissions had contributed to the observed foliar injury, but the negative histology results failed to confirm that fluoride emissions were the primary cause. Compared to previous years' observations, sumac thickets in the south shore immediate impact area were less severely injured in 1985.

Cherry and Plum Trees

Observations in June in the south shore immediate impact area directly across from RMC revealed F-like foliar injury on the following trees: pin and choke cherry trees to the neighbouring west and east of the bridge, a young black

cherry at the river's edge to the west of the bridge, and young plum trees planted by the writer in 1984 just west of the bridge.

In June, injured cherry and plum foliage displayed reddish necrosis at the leaf margins and/or tips and inward cupping. Also observed was injured leaf tissue abscising from the affected foliage. In addition, older pin cherry leaves were savoyed in many cases. By July, much of the necrosis had abscised, and by August only the older foliage displayed evidence of earlier injury, with the younger leaves being healthy. The severity of foliar necrosis observed on the injured pin and choke cherry trees and plum trees in the south shore bridge area in June, when the injury was most pronounced, was trace (0-1%) to light (2-10%) for the most part. The injured black cherry at the river's edge exhibited mostly light (2-10%) to moderate (11-35%) injury, with a few mature leaves having severe injury through to August.

The observations to the more remote northeast also revealed F-like foliar injury of light (2-10%) severity on a pin cherry growing beside the river to the south of the N. Point forage site.

Moreover, on the A. Boots property, as in previous years, two black cherry trees exhibited several leaves with marginal and intercostal reddish spots throughout the summer and appeared thin in August. However, the foliar injury displayed by these trees was not as F-like as that observed on the injured cherry and plum trees in the south shore bridge area and the injury severity was out of context relative to the condition of neighbouring wild grape plants and other fluoride-sensitive vegetation in the area. Histological and pathological results (Table 9) further

failed to suggest that fluoride emissions were the primary causal agent.

The observations through to August also revealed possible F-injury to plum trees on the A. Boots, N.Point and L. Point properties. All displayed some leaves with reddish tip necrosis of trace severity with the exception of a mature plum tree on the N. Point property. This tree, during July and August, displayed light (2-10%) to moderate (11-35%) brownish marginal necrosis on most leaves and its condition also was out of context relative to the other plums and to other sensitive vegetation in the area. Therefore, it is not considered likely that the foliar injury observed on the mature plum tree on the N. Point property was primarily related to fluoride emissions, and the negative histology results (Table 9) would further support this claim.

Compared to the 1984 observations, in 1985 the severity of F-like injury observed on cherry and plum trees growing in and near the south shore immediate impact area appeared to be slightly reduced.

Trembling Aspen and Serviceberry

The observations in the south shore immediate impact area through to August also revealed peculiar foliar injury on trembling aspens growing to the neighbouring west and east of the bridge. In June, when the injury was most pronounced, affected trees displayed several leaves with distinct marginal blackish necrosis of light (2-10%) to moderate (11-35%) severity. Histological analysis (Table 9) confirmed that the injury was typical of fluoride. In July and August, the injury was observed only on mature leaves which were small and cupped. The absence of peculiar foliar injury on more remote trembling aspens would suggest that fluoride

emissions had contributed to the observed injury on trembling aspen trees growing in the south shore immediate impact area.

In June, a small serviceberry tree growing in the south shore area to the west of the bridge where the most severe foliar injury was observed on wild grape, also displayed several leaves with peculiar injury (blackish-brown marginal necrosis and inward cupping). The affected leaves on this tree displayed either light (2-10%) or moderate (11-35%) injury through to August.

Red and Silver Maple

Red maples growing in the south shore area woodlot just east of the bridge and on the L and N. Point properties to the slightly more remote northeast, displayed distinct F-like injury (blackish tips and/or marginal injury) on both mature and younger leaves by July. The injury observed at these locations was mostly in the trace (>0-1%) to light (2-10%) range with some leaves displaying moderate injury through to August. Histological examination of the injured foliage collected from the N. Point property in June confirmed that the injury was typical of fluoride.

The red maples growing in the south shore woodlot to the west of the bridge and on the A. Boots property exhibited less severe foliar injury of trace (>0-1%) to very light (2-10%) severity. F-like blackish tip necrosis of trace severity also was observed on some of the young silver maples growing along the north limit of the A. Boots garden.

Observations at more remote sites during 1985 revealed similar foliar injury (F-like blackish necrosis) and, in some cases, even more severe injury on red and silver maples at other locations on the island as well as on the mainland.

Scattered trees on the mainland as far away as Morrisburg and Monkland to the remote west and north of Cornwall displayed the injury.

In light of the more remote site observations, there is some doubt that the foliar injury observed on red and silver maples in the south shore bridge area of Cornwall island was entirely related to fluoride emissions. However, in view of the analytical data, and the histological results for the injured red maple foliage collected from the N. Point property in June, it is concluded that fluoride emissions had contributed to at least some of the foliar injury that was observed to the immediate northeast of RMC during 1985. Overall, the severity of F-like foliar injury observed on red and silver maples in the south shore bridge area and to the neighbouring northeast during 1985 was similar to that observed in 1984.

Manitoba Maple

In the south shore immediate impact area, Manitoba maples, including collection Site I, displayed mature leaves with marginal chlorosis and/or tan necrosis and cupping during June through August.

In July and August, F-like injury (orange-red marginal necrosis and chlorosis) was pronounced on younger foliage of Manitoba maples across the island and mainland.

However, as recent years' observations during the latter part of the summer have revealed F-like foliar injury on Manitoba maples at distances well beyond possible effects of RMC emissions, Manitoba maples cannot be regarded as reliable indicators of fluoride injury. Nonetheless, in light of the fact that fluoride levels were well above normal in the Manitoba foliage collected in August (337 ppm) from the south

shore immediate impact area, and as other sensitive vegetation (wild grape, etc.) was injured throughout this area, it is likely that fluoride emissions were responsible for at least some of the foliar injury observed on Manitoba maples to the immediate northeast of RMC during 1985.

Pine Needle Assessment

As in 1984, F-like reddish necrosis was observed on red pine needles only on the N. Point property to the neighbouring northeast of the south shore bridge area. However, in contrast with 1984, only some current year's needles were affected on a single red pine on this property with the average injury being less than 1%. The observations in 1984 had revealed injury to several current year's needles on several red pines and average injury of about 10%.

All other pines examined on Cornwall Island in 1985, including the Eastern white pines growing in the south shore area woodlots to the west and east of the bridge, failed to display any peculiar injury to the current year's needles.

Cultivated Grape Assessment

Cultivated grape plants were examined in the A. Boots garden in June, July and August and on the E. Benedict and A. Lazore properties in July and August. The abandoned, very weedy vineyard (owned by N. Gaspy) situated just east of the R. Pearce forage site was examined only in July.

F-like foliar injury was initially observed in July only at the A. Boots site which was the closest site to the northeast of RMC. In July, and again in August, tip necrosis and, in some cases, marginal necrosis was observed on some mature leaves at this location, with the injury severity remaining

trace (>0-1%) through to August. At the other cultivated grape sites, located at the center and east end of the island, only tip necrosis of trace (>0-1%) severity was observed on some mature leaves in August.

The severity of F-like injury observed on cultivated grape foliage on Cornwall Island during 1985 was comparable to that observed in previous years, with the injury in 1985 possibly being slightly less severe than in 1984.

Garden Crops Assessment

The observations in July and August on the A. Boots property to the neighbouring northeast of the south shore bridge area, revealed several sweet corn plants (white corn) with middle leaves displaying a distinct zone of chlorotic-yellowish tissue on both sides of the mid-rib at or near the arch. Similar injury and pattern also was observed on several corn plants growing on the L. Thompson property (see Figure 3) to the slightly more remote northeast of RMC. All other sweet corn plantings examined to the neighbouring north and northeast of RMC and at more remote locations across the island failed to display any peculiar foliar injury. On the basis that the previously noted foliar injury and pattern was observed, as in 1984, only on corn plantings in the immediate area of RMC, it was initially suspected that fluoride emissions were the primary contributor.

However, the injured corn foliage sampled in August from the A. Boots garden had a low fluoride level (4 ppm) and histological examination of the foliar injury did not reveal a typical fluoride injury pattern (unlike in 1984). Therefore, it cannot be concluded that fluoride emissions were a contributing factor in 1985.

Other garden crops examined across the island in 1985, as in other years, did not display any foliar injury which was believed to be related to fluoride emissions.

Gladiolus Assessment

Mixed gladiolus varieties were examined on or near three locations (Mrs. Leaf, P. Caldwell, P. Martin) in July and August. In August, glads also were examined on the G. Charrow property. All properties were situated to the west of the bridge with the exception of the Martin property which was located in the south shore immediate impact area just east of the bridge (see Figure 3).

In July and August, F-like foliar injury was observed on glads growing on the Martin property to the immediate northeast of RMC. At this location, several glads displayed reddish necrosis extending from the tip down one or both sides of some leaves. The severity of injury to the more adversely affected leaves was judged to be moderate (11-35%) in August. In August, glads growing on the G. Charrow property in the south shore area to the immediate north of RMC also displayed some leaves with trace (>0-1%) F-like injury and pattern. The glads examined at more remote locations during July and August were in a normal condition.

G. RESULTS OF HISTOLOGICAL AND PATHOLOGICAL EXAMINATIONS

Results of histological and pathological examination of foliage samples collected from the RMC survey area during 1985 are shown in Table 9. Flouride injury to the trembling aspen in the south shore bridge area, and to red pine and red maple at the N. Point site, was confirmed.

IV. RESULTS OF ENVIRONMENT CANADA AIR MONITORING PROGRAM AND METEOROLOGICAL ASPECTS - 1985

In 1985, Environment Canada discontinued air monitoring at Station A (customs) and Station C (west end of island) and maintained only Station B on the Elijah Benedict property (center of Cornwall Island), where air monitoring has been conducted each year since 1976. As in previous years, a wind recorder was maintained at Station C at the west end of Cornwall Island. The wind recorder was situated on the roof of Station C, approximately 3-4 meters above the ground. The complete synopsis of the 1985 Environment Canada air and wind monitoring results is attached for reference.

During the 1985 growing season, Environment Canada found that ambient fluoride concentrations and the number of exceedances of Ontario's air quality criteria were reduced compared to 1984. The historical summary of the 24 hr average fluoride concentrations showed that the 1985 levels of both gaseous and particulate fluoride recorded at Station B (center of island) were lower than the record low concentrations found in 1982.

Environment Canada also found during the May-October recording period that winds were predominantly from the south and southeast (during 1976-84 winds prevailed from the southwest and west) and that the percentage of SW winds blowing into the survey area was reduced compared to earlier years (1976-84).

The frequency of wind and rain and total rainfall recorded at the Ontario Hydro (OH) climatic station, Cornwall, during the shorter four month May through August period are compared to the corresponding earlier years' data in Table 10. The OH wind recorder is situated about 55 metres above the ground on a microwave tower which is located approximately 500 metres south of Hwy 401 off Power Dam Road to the northwest of Cornwall.

In contrast to the Environment Canada findings, the OH wind data revealed that west and southwest were the prevailing wind directions and that there was the normal frequency of southwest winds during May through August, 1985, when compared to the corresponding previous years' data.

The wind data discussed above represent different recording periods and the cut-off speed for calm used by Environment Canada (3 km/hr) is different from the one used by Ontario Hydro (0 km/hr). These and other factors, such as differences in location and in height above ground of the recorders likely would account for much of the discrepancy between the two data sets. It is likely that the St. Lawrence River also is influencing the wind patterns monitored each summer on Cornwall Island.

The rainfall recorded at the OH climatic station during May through August is summarized and compared to the norms and to the corresponding earlier years data in Table 10.

As shown in this Table, June was unusually wet and the total rain received in July and August was slightly below normal. Overall, there was more total rain in 1985 than in most previous years (1978-84) and this largely was due to the record amount received in June.

In view of both the air monitoring data and the meteorological data for the Cornwall area, it is suspected that the improvement in air quality and decrease in fluoride contamination found in the RMC survey area during the 1985 growing season were related more to weather than to any major reduction in fluoride emissions from RMC.

V. ALCOA ASSESSMENT PROGRAM - 1985

A. PRIMARY OBJECTIVE

The main objective of the 1985 ALCOA assessment program was to determine the degree and extent of fluoride contamination and injury to native vegetation and to compare these findings with previous years' results.

B. SAMPLING AND INJURY ASSESSMENT PROGRAMS

During late August (as in other years), triplicate samples of Manitoba maple foliage were collected from the exposed side at six collection sites in the Long Sault area to the north and northeast of ALCOA. All samples were processed on a washed and unwashed basis and were submitted on a dry weight basis to the Inorganic Trace Contaminants Section, Laboratory Services Branch, MOE, to be analyzed for fluoride, aluminum and sodium.

Also during August, sensitive vegetation (e.g. wild grape, pines) in the survey area was examined for fluoride injury.

C. ANALYTICAL RESULTS (COMPARISON TO PREVIOUS YEARS' RESULTS AND TO MOE GUIDELINES)

In 1985, foliar fluoride levels were moderately increased at Site 1 to the north of ALCOA and markedly reduced at maple sites to the northeast (Sites 4, 6, 7, 8), compared to the corresponding 1984 results.

As in more recent years (1982-84), the highest foliar fluoride levels (unwashed - 50 ppm; washed - 35 ppm) were detected at maple Site 7 located 9.6 km northeast of ALCOA

(see Table 11 and Figure 2). Similar elevated foliar levels were detected at Site 1 to the north.

The Long Sault area is rural and, as in other years, the mean fluoride level detected at most sites in August exceeded the upper limit of normal for a rural area (15 ppm). The mean fluoride level detected at foliage collection Site 7 (50 ppm) and Site 1 (47 ppm) also slightly exceeded the 35 ppm urban guideline. The Site 1 exceedance was only the second such occurrence since 1976. Foliar fluoride levels in excess of the 35 ppm guideline have been detected at one or two locations in the survey area each year since 1976, except for 1984, when exceedances occurred at four locations.

As in 1984, even the highest unwashed foliar levels of aluminum (90 ppm - Site 1) and of sodium (46 ppm - Site 1) detected in the survey area were not found to be appreciably elevated when compared to the upper limit of normal guidelines for aluminum (500 ppm) and sodium (50 ppm - rural; 350 ppm - urban).

D. VISUAL FINDINGS

On wild grape, as in most other years, trace (>0-1%) to very light (<5%) F-like injury (tip necrosis mainly) was observed on some mature leaves in the vicinity of most maple sites (2, 6, 7 and 8). The severity of F-like injury observed at all affected grape sites was fairly uniform, in contrast with 1984 when considerably more injury (moderate to severe) was observed on grape plants near maple Site 7 than at other sites.

In general, the injury observed on wild grape plants in the Long Sault area in 1985 was less severe than in 1984 and was comparable to the pre-1984 injury assessment findings. Other vegetation examined in the survey area failed to display any foliar injury which was believed to be related to ALCOA emissions.

VI. SUMMARY OF RMC AND ALCOA SURVEY FINDINGS - 1985

A. RMC SURVEY

The main findings for the RMC survey area can be summarized as follows:

1. RMC emissions, as in previous years, resulted in the highest levels of fluoride, aluminum and sodium in vegetation in the south shore bridge area of Cornwall Island, and fluoride levels were found to sharply decrease with distance from this area.

2. Fluoride levels in unwashed maple foliage, pine needles and forage from Cornwall Island generally were reduced in 1985, with the forage results being markedly reduced compared to 1984.

3. Unwashed fluoride levels found in August at all foliage collection sites exceeded the 15 ppm upper limit of normal guideline established for a rural area by the Phytotoxicology Section, with contamination extending to the NE to a distance of at least 13 km.

4. There was a decrease in the number of exceedances of the MOE forage criteria, with only one exceedance being recorded in 1985 compared to eleven in 1984, four in 1983 and three in 1982. The single exceedance documented in

1985 was at the Bridge site in the south shore immediate impact area.

5. Unwashed foliar levels of sodium detected at most sites in August exceeded the upper limit of normal guideline for a rural area (50 ppm). Only the level found at Site 1, in the south shore area, was in excess of the 350 ppm urban guideline.

6. Foliar fluoride-like injury was observed on the same deciduous species injured in 1984, as well as on trembling aspen and serviceberry. As in previous years, the most adverse effects generally were confined to the south shore immediate impact area of the island. Sensitive vegetation (e.g. wild grape) displayed slightly less severe injury compared to 1984, but generally there was no dramatic change in the degree or extent of fluoride injury to deciduous vegetation compared to most previous years' observations.

7. On conifers, fluoride-like injury was observed, as in 1984, only on current year needles of red pine on the Noah Point property to the neighbouring northeast of the south shore bridge area.

8. Of the numerous garden crops examined on Cornwall Island, peculiar foliar injury and pattern was observed, as in 1984, only on sweet corn plants in the immediate area of RMC. However, the analytical results and the negative histopathological results failed to confirm that fluoride emissions were the primary cause.

In conclusion, the degree and extent of fluoride contamination to vegetation generally was reduced in 1985, with the forage results showing a marked decrease compared to 1984.

The severity of injury to sensitive vegetation also was slightly reduced but overall there was no dramatic change in the degree or extent of injury to vegetation in the survey area compared to other years. As in previous years, the highest degree of foliar contamination and most adverse injury to vegetation was confined to the south shore bridge area (immediate impact area) of the island, to the neighbouring northeast of RMC.

In view of the Environment Canada air monitoring results and the meteorological data previously discussed, it is suspected that the reduction in fluoride contamination found in 1985 was likely related more to weather than to any major reduction in fluoride emissions from RMC.

B. ALCOA SURVEY

The major findings for the ALCOA survey area can be summarized as follows:

1. In 1985, unwashed foliar levels of fluoride were moderately increased at Site 1 to the north of ALCOA and were markedly reduced at maple Sites 4, 6, 7 and 8 to the northeast, compared to 1984.

2. As in 1982 through 1984, the highest unwashed and washed foliar fluoride levels were detected to the northeast at maple collection Site 7.

3. Fluoride levels in excess of 35 ppm were detected at two sites in 1985, compared to four in 1984 and 1 or 2 sites in earlier years.

4. As in most previous years, trace to very light F-like injury was observed only on sensitive wild grape foliage

with the injury severity observed throughout the survey area being reduced in 1985 compared to 1984. The injury severity observed in 1985 was comparable to the pre-1984 injury assessment results.

In conclusion, foliar fluoride levels at most maple collection sites in the Long Sault survey area generally were lower than in 1984. F-like injury observed on sensitive vegetation also was less severe than 1984, with the severity of injury observed at affected grape sites in 1985 being similar to that observed during most earlier years. The fact that foliar fluoride contamination and injury to sensitive vegetation also was reduced in the nearby RMC survey area would further suggest that weather variations, as opposed to any major reduction in emissions from ALCOA, were more likely responsible for the decrease in fluoride contamination in the Long Sault area in 1985.

TABLE I

Comparison Of Fluoride Levels Detected At All Regular Manitoba Maple Foliage Collection Sites In Late August, 1982 Through 1985

Site No.	General Location*	Distance (Km) & Direction from RMC	Concentration - ppm, dry weight							
			1982		1983		1984		1985	
			NW[a]	W[a]	NW[b]	W[b]	NW[b]	W[b]	NW[b]	W[b]
1	S shore-bridge (Is)	1.5 NE	380	180	293 ± 15.3	173 ± 25.2	389 ± 35.2	304 ± 33.1	337 ± 8.5	228 ± 24.4
33	A. Boots (Is)	1.9 NE	-	-	123 ± 5.8	61 ± 12.3	117 ± 18.1	79 ± 8.6	71 ± 22.4	59 ± 16.5
3	P. Hopps (Is)	3.1 NE	70	48	97 ± 15.3	68 ± 17.0	113 ± 10.0	106 ± 16.4	92 ± 8.1	83 ± 2.5
6	E. Benedict (Is)	4.1 NE	28	20	48 ± 6.2	25 ± 3.8	57 ± 5.5	38 ± 7.0	48 ± 6.1	32 ± 6.8
13	Cornwall (M)	6.0 NE	57	24	57 ± 6.2	26 ± 2.5	68 ± 5.0	50 ± 1.5	45 ± 6.1	31 ± 2.1
7	A. Lazore (Is)	6.8 NE	15	15	37 ± 4.6	15 ± 4.6	39 ± 2.3	25 ± 2.5	33 ± 1.0	27 ± 2.9
14	Cornwall (M)	8.3 NE	28	12	37 ± 3.2	23 ± 6.6	40 ± 4.6	32 ± 5.7	32 ± 3.6	17 ± 1.7
19	NE of Cornwall (M)	9.7 NE	25	15	30 ± 8.7	19 ± 3.5	34 ± 1.7	27 ± 2.1	35 ± 5.2	19 ± 0.6
17	NE of Cornwall (M)	13.2 NE	26	14	36 ± 2.5	22 ± 0	33 ± 2.9	24 ± 3.0	25 ± 1.0	18 ± 1.7
2	Customs Area (Is)	2.0 NNE	25	13	57 ± 1.5	12 ± 3.5	63 ± 12.9	58 ± 4.6	50 ± 11.9	32 ± 11.8
4	Cornwall (M)	4.7 NNE	66	17	63 ± 9.1	22 ± 1.2	42 ± 5.6	29 ± 7.4	27 ± 3.5	19 ± 2.7
5	Cornwall (M)	6.4 NNE	18	12	21 ± 3.1	12 ± 2.5	26 ± 3.8	21 ± 2.3	26 ± 2.1	17 ± 2.5
12	NE of Cornwall (M)	8.5 NNE	28	13	27 ± 1.7	10 ± 0.6	38 ± 2.1	26 ± 2.5	53 ± 8.5	26 ± 7.2
8	J. Thompson (Is)	1.9 N	12	8	27 ± 4.2	14 ± 4.0	23 ± 4.2	18 ± 2.3	32 ± 8.7	21 ± 8.2
9	R. Seymour (Is)	2.5 N	18	15	19 ± 1.0	13 ± 1.2	14 ± 2.5	12 ± 1.0	22 ± 4.0	16 ± 2.0
20	S shore - E end (Is)	6.1 ENE	17	12	31 ± 1.2	14 ± 3.8	41 ± 2.9	28 ± 4.0	26 ± 3.5	18 ± 3.5

* (Is) - Cornwall Island; (M) - Mainland

a - based on a single sample; b - average of triplicate results ± std. deviation.
NW - foliage left unwashed
W - foliage washed prior to drying and analysis

Table 2

Comparison Of Particulate Removal Values For The Manitoba Maple Foliage Samples Collected In Late August, 1982 Through 1985, Based On The Unwashed (NW) And Washed (W) Fluoride Results In Table 1

Site No.	General Location*	Distance (Km) & Direction from RMC	Percent (%) Particulate Removed From Foliage By Washing[a] 1982	1983	1984	1985
1	S shore-bridge (Is)	1.5 NE	53	41	22	32
33	A. Boots (Is)	1.9 NE	-	50	32	17
3	P. Hopps (Is)	3.1 NE	31	30	6	10
6	E. Benedict (Is)	4.1 NE	29	48	33	33
13	Cornwall (M)	6.0 NE	58	54	26	31
7	A. Lazore (Is)	6.8 NE	0	59	36	18
14	Cornwall (M)	8.3 NE	57	38	20	47
19	NE of Cornwall (M)	9.7 NE	40	37	21	46
17	NE of Cornwall (M)	13.2 NE	46	39	27	28
2	Customs Area (Is)	2.0 NNE	48	79	8	36
4	Cornwall (M)	4.7 NNE	74	65	31	30
5	Cornwall (M)	6.4 NNE	33	43	19	35
12	NE of Cornwall (M)	8.5 NNE	54	63	32	51
8	J. Thompson (Is)	1.9 N	33	48	22	34
9	R. Seymour (Is)	2.5 N	17	32	14	27
20	S shore - E end (Is)	6.1 ENE	29	55	32	31
Mean ∓ standard deviation			40 ∓ 18	49 ∓ 13	24 ∓ 9	32 ∓ 11

* (Is) - Cornwall Island; (M) - Mainland

[a] Calculated from the following formula: $\frac{NW - W}{NW} \times 100$

TABLE 3

Fluoride Results For Unwashed Manitoba Maple Foliage Collected In The Cornwall Area Near The End Of August: 1972-1985

Site No.	Site Location Is - Island M - Mainland	Approximate Distance (Km) and Direction from RMC	••Average Unwashed Fluoride Concentration (ppm - dry wt.)												
			1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982[a]	1983[a]	1984[a]	1985[a]
1	E of Bridge - S. Shore (Is)	1.5 NE	451	597	516	1,171	550	750	193	197	143	192	380	293	389	337
33	A. Boots (Is)	1.9 NE	-	-	-	-	-	-	-	-	-	-	-	123	117	71
3	P. Hopps (Is)	3.1 NE	-	-	-	-	122	217	32	57	60	86	70	97	113	92
6	E. Benedict (Is)	4.1 NE	317	244	98	235	114	56	22	32	23	71	28	48	57	48
13	Cornwall (M)	6.0 NE	-	-	-	-	-	-	16	29	15	64	57	57	68	45
7	A. Lazore (Is)	6.8 NE	90	-	79	100	116	37	23	21	15	64	15	37	39	33
14	Cornwall (M)	8.3 NE	-	-	-	-	-	-	17	14	10	44	28	37	40	32
19	Cornwall (M)	9.7 NE	-	-	-	-	-	-	18	18	20	50	25	30	34	35
17	Cornwall (M)	13.2 NE	-	-	-	-	-	-	11	13	25	39	26	36	33	25
2	Customs (Is)	2.0 NNE	-	-	-	-	123	138	17	31	10	50	25	57	63	50
4	Cornwall (M)	4.7 NNE	-	-	-	-	-	-	29	34	45	45	66	63	42	27
5	Cornwall (M)	6.4 NNE	-	-	-	-	-	-	21	19	25	46	18	21	26	26
12	Cornwall (M)	8.5 NNE	-	-	-	-	-	-	25	42	10	74	28	27	38	53
8	J. Thompson (Is)	1.9 N	30	-	76	60	29	45	15	21	8	18	12	27	23	32
9	R. Seymour (Is)	2.5 N	-	-	-	66	31	14	7	15	5	26	18	19	14	22
20	E End of Island (Is)	6.1 ENE	-	-	-	-	-	-	6	15	3	29	17	31	41	26

a Ion selective electrode method used; prior to 1982 the Alkali fusion method was used.

•• Averages for 1975-79; 1983-85 are based on triplicate collections. A single composite sample was collected at each site in 1980-1982 and prior to 1975.

TABLE 4

Levels Of Aluminum And Sodium In Unwashed Manitoba Maple Foliage Collected In August Of 1982 Through 1985

Site No.	General Location*	Distance (km) & Direction from RMC	Concentration - parts per million - dry weight							
			Aluminum				Sodium			
			1982[a]	1983[b]	1984[b]	1985[b]	1982[a]	1983[b]	1984[b]	1985[b]
1	S shore-bridge (Is)	1.5 NE	174	181	193	217	520	373	480	420
33	A. Boots (Is)	1.9 NE	-	131	130	62	-	253	287	160
3	P. Hopps (Is)	3.1 NE	74	99	107	84	245	157	223	143
6	E. Benedict (Is)	4.1 NE	32	79	69	78	112	107	109	100
13	Cornwall (M)	6.0 NE	98	123	160	86	125	127	267	117
7	A. Lazore (Is)	6.8 NE	70	110	103	137	48	67	95	89
14	Cornwall (M)	8.3 NE	52	96	96	87	64	97	92	66
19	NE of Cornwall (M)	9.7 NE	100	121	153	96	128	103	83	58
17	NE of Cornwall (M)	13.2 NE	68	106	107	99	64	117	106	75
2	Customs-Island Rd. (Is)	2.0 NNE	96	128	83	90	132	70	85	81
4	Cornwall (M)	4.7 NNE	90	130	100	61	130	97	87	67
5	Cornwall (M)	6.4 NNE	43	75	57	68	66	70	70	72
12	NE of Cornwall (M)	8.5 NNE	111	79	125	137	53	57	74	72
8	J. Thompson (Is)	1.9 N	51	96	57	115	85	77	68	64
9	R. Seymour (Is)	2.5 N	49	66	26	58	125	43	61	34
20	S shore - E end (Is)	6.1 ENE	80	110	81	74	53	77	99	105

* (Is) Cornwall Island
(M) Mainland Cornwall Area

a - based on a single sample collected at each site.

b - mean of triplicate results for each site.

TABLE 7

Monthly Fluoride Levels Detected In Unwashed Forage Collected On Cornwall Island And Mainland During 1985 And Corresponding Seasonal (May - Oct.) Means For 1978-1985

Site Location (in order of increasing distance from RMC)	Approximate Distance (Km) and Direction from RMC	Monthly Fluoride Concentration (parts per million, dry weight)						Seasonal Mean Fluoride Concentration[a] 1978-1985 (parts per million, dry weight)							
		May	June	July	Aug.	Sept.	Oct.	1985[d]	1984[d]	1983[d]	1982[b]	1981[b]	1980[b]	1979[d]	1978[d]
Bridge Site (uncut)	1.5 NE	58	34	41	40	17	25	36	92	52	41	68	52	51	58
N. Point (grazed)	2.0 NE	29	15	15	11	9	13	15	36	30	25	34	28	20	31
P. Hopps (grazed)	3.1 NE	21	21	5	9	9	15	13	25	19	13	35	17	11	17
Dump Site (hayfield)	3.3 NE	21	8	7	6	6	13	10	24	15	14	26	16	9	12
E. Benedict (grazed)	4.1 NE	10	17	4	7	10	14	10	16	18	12	25	14	12	12
R. Pearce (grazed)	4.6 NE	9	11	3	5	6	8	7	16	18	11	23	16	10	14
N. Hopps (hayfield)	5.7 NE	5	4	2	5	6	7	5	14	13	9	18	7	9	9
A. Lazore (hayfield)	6.8 NE	4	3	2	2	5	6	4	11	11	6	15	9	9	8
D. Farlinger - M (hayfield)	9.2 NE	3	2	3	6	6	11	5	11	11	9	-	-	-	-
McGee - M (hayfield)	11.8 NE	3	2	2	4	4	6	4	7	-	-	-	-	-	-
P. Caldwell (hayfield)	1.8 NNE	6	2	2	17	5	9	7	15	12	13	-	-	-	-
J. Thompson (grazed)	1.7 N	3	5	8	11	14	9	8	13	11	10	22	12	10	12
R. Seymour (grazed)	2.5 N	4	2	2	6	6	6	4	9	9	7	21	7	6	5
W tip of Island (hayfield/grazed)	1.6 NNW	3	2	2	3	6	5	4	9	5	7	-	-	-	-
Lunenburg - M (hayfield)	17.7 WNW	3	2	2	2	3	4	3	3	3	3	-	-	-	-

a - all 1982 - 1985 results based on Ion Selective Electrode method; Alkali Fusion Method used for analysis in 1978-81.

b - based on a single sample.

d - based on triplicate samples.

M - site on Mainland; all other sites are on the Island.

TABLE 8

Average (June - July - August) Fluoride Results For Unwashed Forage Sampled On Cornwall Island - 1970-1985

Site Location (order of increasing distance from RMC)	Approximate Distance (Km) & Direction	*Average Fluoride Concentration (parts per million - dry weight basis)																
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1982[a]	1983[a]	1984[a]	1985[a]
Bridge Site	1.5 NE	597	361	137	128	192	-	-	88**	72	43	43	71	32	36	48	123	38
L. Point; N. Point	2.0 NE	-	-	66	71	76	116	51	95	37	16	23	29	28	18	18	53	14
P. Hopps	3.1 NE	-	-	-	-	-	-	32	30	20	9	18	37	23	10	18	36	12
Dump Site	3.3 NE	-	-	-	-	-	-	-	-	13	6	12	26	21	9	10	31	7
E. Benedict	4.1 NE	64	79	56	54	29	71	21	23	14	11	13	25	23	10	17	23	9
R. Pearce	4.6 NE	-	-	-	-	-	-	-	-	14	10	15	22	21	8	17	21	6
N. Hopps	5.7 NE	-	-	-	-	-	-	13	11	9	9	7	21	14	6	9	19	4
A. Lazore	6.8 NE	-	-	11	14	13	21	11	13	9	8	7	15	13	5	7	12	3
Customs - Island Road (1977-1981)	2.0 NNE	-	-	-	-	-	-	-	19**	15	8	11	22					
P. Caldwell - 1982 on	1.9 NNE	-	-	-	-	-	-	-	-	-	-	-	-	15	8	7	18	7
J. Thompson	1.7 N	-	-	11	36	26	72	6	19	8	10	11	15	14	7	9	15	8
R. Seymour	2.5 N	18	14	7	-	28	38	7	14	6	5	8	17	11	5	7	10	3
W Tip of Island	1.6 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	9	3

*1969-1974; 1980-1982 averages based on a single composite sample collected at each site per month.

1975-1979; 1983-85 averages based on the results of triplicate samples collected monthly at each site.

** average based on estimated level for June

a 1982-85 results based on Ion Selective Electrode method; in earlier years, the Alkali Fusion method was used

Table 9

Results of Histological and/or Pathological Examination of Foliage Samples Collected from Cornwall Island During 1985

Sampling Date	General Location/Property	Foliage Type	General Description of Injury	Results of Examination(s)		
		Samples Collected for Histological Examination		Typical of Fluoride	Some Similarity	Not Typical
June 19	S Shore - W of Bridge	Staghorn Sumac	intercostal blackish necrosis			X
	"	Trembling Aspen	blackish necrosis at margins	X		
	"	Manitoba Maple	intercostal chlorosis			X
	"	Beech	intercostal chlorosis & reddish necrosis			X
	S Shore - E of Bridge	Red Ash	marginal reddish necrosis			X
	N. Point	Red Maple	dark reddish-brown marginal necrosis	X		
July 18	P. Martin	Pepper	blackish surface spots			X
	P. Martin	Tomato	brownish flecks on upper surface			X
	A. Boots	Manitoba Maple	reddish tip necrosis			X
	A. Lazore	Silver Maple	blackish marginal necrosis			X
August 7	A. Boots	Black Cherry	marginal & intercostal reddish necrotic areas			X
	A. Boots	Corn	chlorotic tissue at arch of leaf			X
	L. Thompson	Corn	chlorotic tissue at arch of leaf			X
	L. Thompson	Corn	chlorotic spots/mottling			X
August 28	N. Point	Red Pine	reddish tip necrosis on 1985 needles	X		
	"	Red Maple	blackish-brown marginal necrosis			X
	"	Plum	brown necrosis at margins			X
		Sample Collected for Pathological Examination				
August 7	A. Boots	Black Cherry	marginal & intercostal reddish necrotic areas	Anthracnose (*Gloeosporium serotinum*)		

TABLE 10

Percentage Of Time Winds Were From The S, SW And W And Total Precipitation And Number Of Days With Rain Recorded At The Ontario Hydro Climatic Station, Cornwall - May Through August, 1978-1985

Year	MAY					JUNE					JULY					AUGUST					MAY-AUGUST*					
	% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		
	S	SW	W	Tot	Freq.	S	SW	W	Tot	Freq.	S	SW	W	Tot	Freq	S	SW	W	Tot	Freq	S	SW	W	Tot	Freq	
1978	6	19	31	79	10	6	23	28	71	17	5	33	28	51	9	6	27	25	102	11	6	25	28	303	47	(8)
1979	7	18	19	64	14	6	28	27	41	10	4	27	31	48	10	7	29	24	130	16	6[a]	26[a]	25[a]	283[a]	50[a]	
1980	6	19	23	39	7	3	17	33	38	12	5	25	33	114	19	5	21	22	137	13	5	21	28	292	49	(5)
1981	6	15	24	109	15	7	23	34	95	14	4	17	31	69	8	10	15	28	122	16	6	18	30	382	50	(5)
1982	9	11	19	58	8	5	23	20	86	14	2	24	34	66	10	3	23	33	125	12	5	20	26	324	42	(8)
1983	7	18	24	88	17	4	26	43	79	11	2	28	25	92	11	6	23	29	61	8	5	24	30	317	46	(4)
1984	3	17	39	113	18	4	22	38	55	8	2	26	48	51	11	2	23	34	95	14	3	21	40	296	47	(7)
1985	5	18	21	68	12	5	19	29	148	18	3	32	38	68	11	3	24	23	70	9	4	24	28	336	48	(6)
Norms**	–			70	12	–			70	11	–			76	11	–			99	11	–			–		

* May through to and including date of regular maple foliage collection near end of August: 1978 - Aug. 29; 1979[a] - Sept. 5; 1980 - Aug. 27; 1981 - Aug. 26; 1982 - Aug. 25; 1983 - Aug. 23; 1984 - Aug. 23; 1985 - Aug. 28. a - 1979 May - August* values represent the period May - August 31.

** Rainfall normals taken from Canadian Climate Normals, Atmospheric Environment Service, Environment Canada, Toronto.

(4) Number of days with rain during the two week period prior to maple collection.

TABLE 11

Analytical Fluoride Results For Unwashed Maple Foliage Collected In The Long Sault Area During 1976 To 1985

Site No.	Distance & Direction from ALCOA		*Fluoride Concentration (parts per million - dry weight)									
			1976 Sept. 1	1977 Aug. 29	1978 Aug. 29	1979 Sept. 6	1980 Aug. 28	1981 Aug. 26	1982 Aug. 26	1983 Aug. 23	1984 Aug. 22	1985 Aug.23
1	4.8	N	34	17	15	59	5 (3)**	22 (12)**	16 (10)**	26 (14)**	25 (17)**	47 (31)**
2	7.9	NNE	13	11	6	11	5 (3)	13 (12)	6 (5)	17 (8)	12 (11)	18 (13)
4	9.5	NE	91	45	29	47	25 (20)	50 (16)	16 (13)	33 (16)	61 (25)	28 (17)
7	9.6	NE	-	35	38	30	15 (5)	34 (12)	28 (22)	39 (23)	106 (62)	50 (35)
6	12.6	NE	57	33	16	13	15 (5)	9 (7)	9 (5)	19 (11)	41 (20)	17 (11)
8	7.1	ENE	-	16	20	16	3 (3)	24 (12)	17 (10)	18 (11)	48 (29)	18 (12)

* 1976-1979; 1983 - 1985 - average of triplicate samples.

1980-82 - based on a single sample.

** ( ) fluoride concentration of washed foliage

Figure 1: Manitoba Maple Foliage And Forage Sites Sampled In The Reynolds Survey Area - 1985.

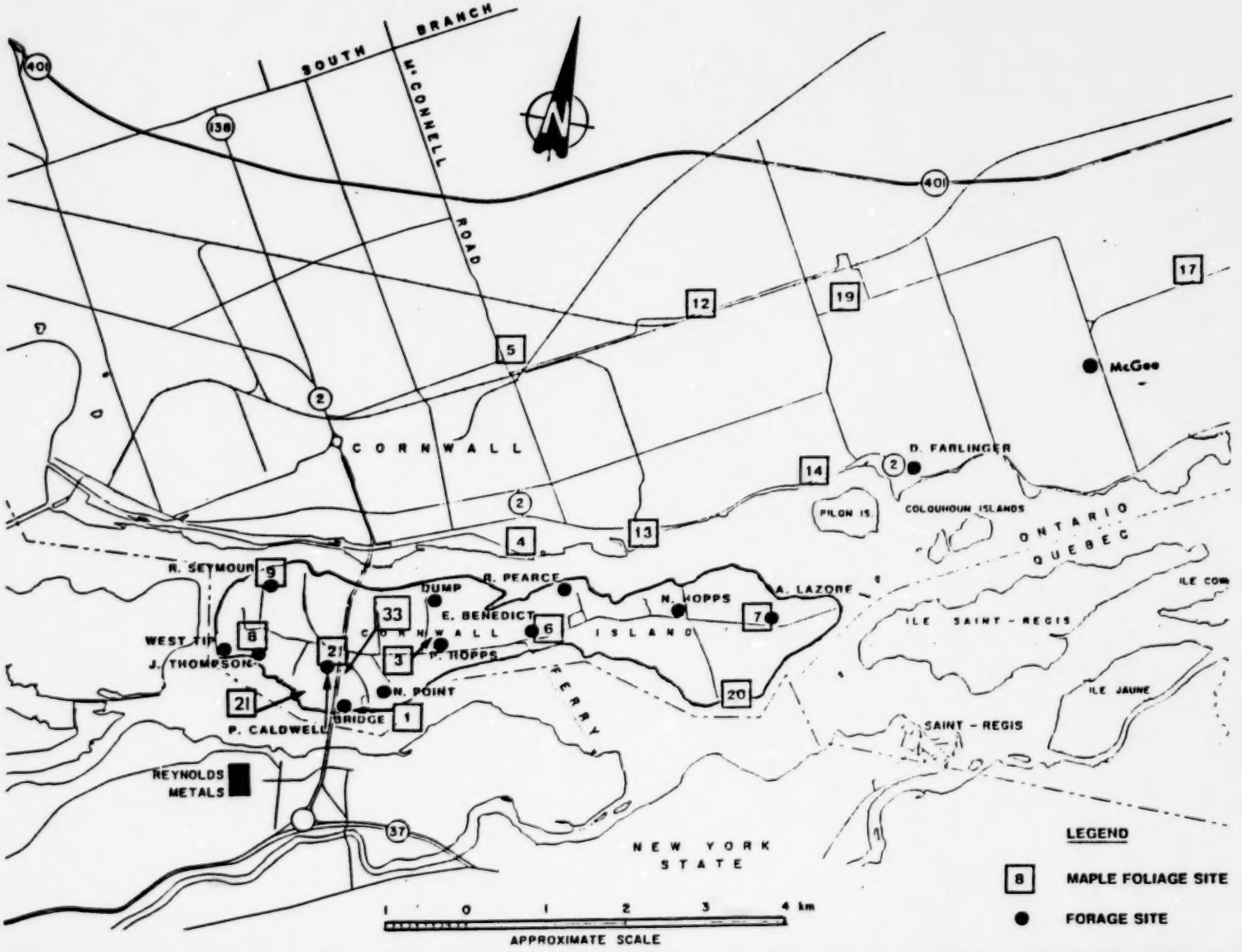

Figure 2: Approximate Location Of Other Tree Foliage Collection Sites In The Reynolds Survey Area And Of Manitoba Maple Foliage Sites To The North And Northeast Of ALCOA - 1985.

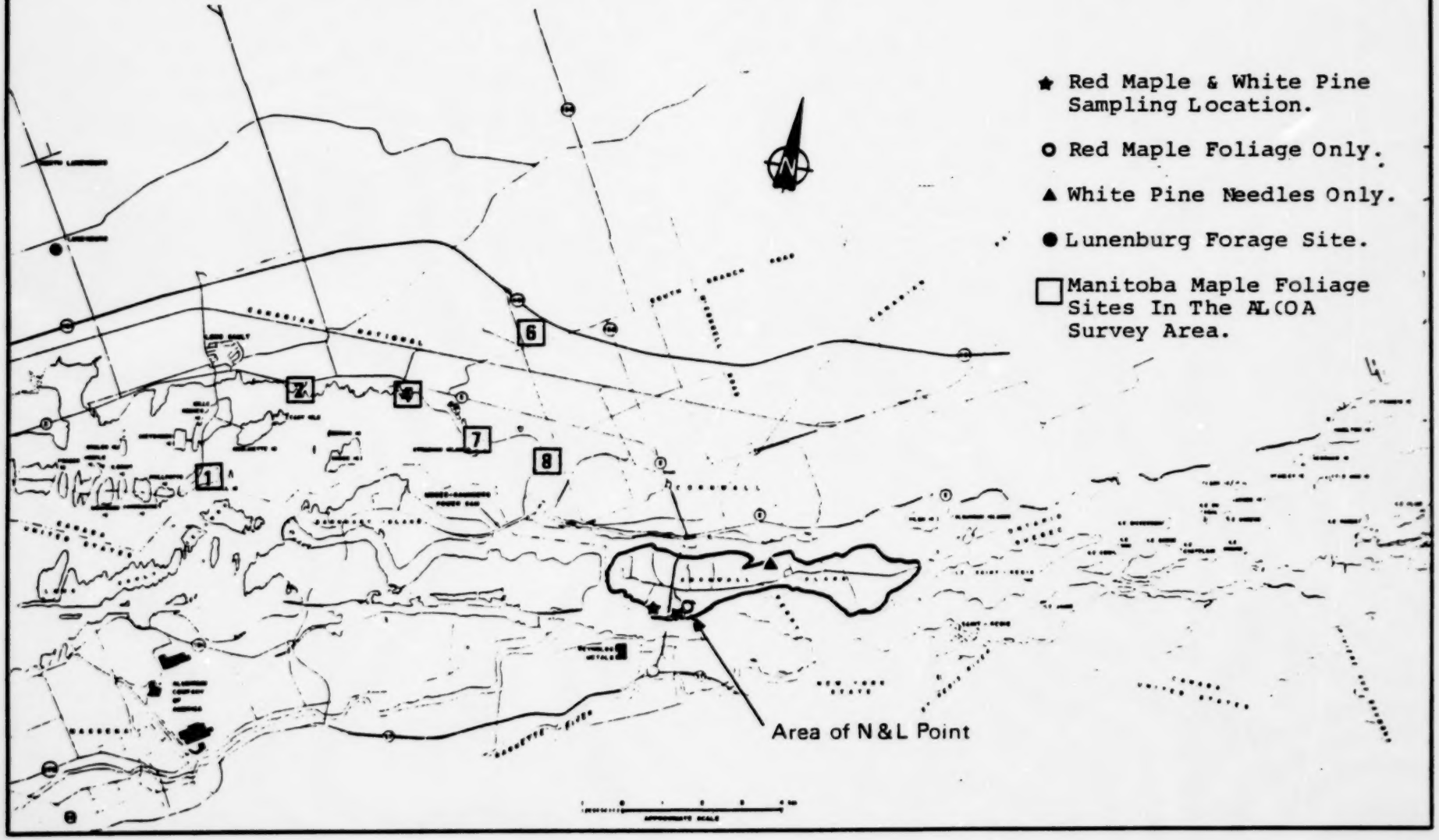

Figure 3: Approximate Location Of The Seventeen Gardens Examined On Cornwall Island During 1985.